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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/677,785	10/01/2003	Kuo-Chun Wu	M-12980 US	9582

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EXAMINER	
NGUYEN, GEORGE BINH MINH	
ART UNIT	**PAPER NUMBER**
3723	

DATE MAILED: 04/12/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

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Office Action Summary	Application No.	Applicant(s)	
	10/677,785	WU ET AL.	
	Examiner	Art Unit	
	George Nguyen	3723	

-- *The MAILING DATE of this communication appears on the cover sheet with the correspondence address* --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 24 January 2005.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-23 is/are pending in the application.

4a) Of the above claim(s) 10-20 is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1-3 18-20, 21 is/are rejected.

7)☒ Claim(s) 4-9,22 and 23 is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date 100103.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: _____.

DETAILED ACTION

Receipt is acknowledged of Applicant's amendment filed on January 24, 2005.

Claims 21-23 were added. Claims 10-17 were still withdrawn from further consideration. Thus, claims 1-9 and 18-23 are presented for examination.

Receipt is acknowledged of the IDS filed on October 01, 2003 which has been considered and placed of record in the file.

Please note this action is not final due to a new ground of rejection based newly discovered art as follows.

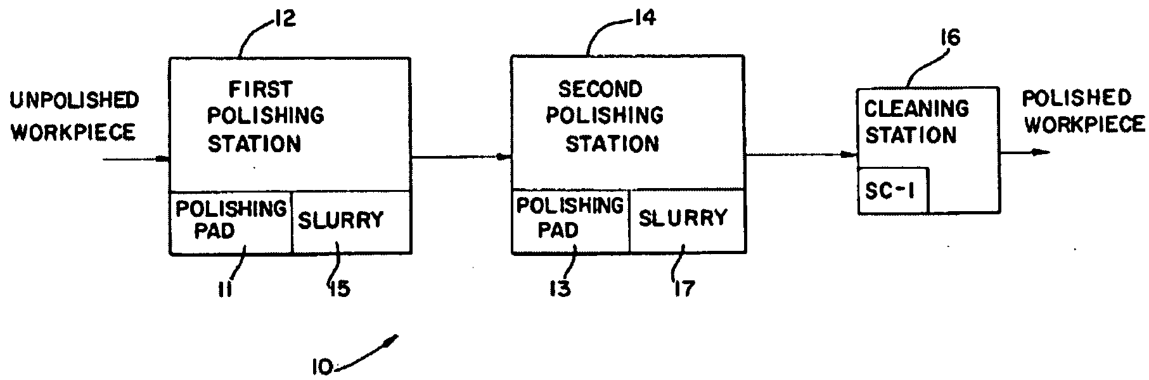
Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claim 21 is rejected under 35 U.S.C. 103(a) as being unpatentable over Mikhaylich et al.'6,431,959 in view Meyer'6,224,465.

With reference to Figure 1, Mikhaylich'959 discloses a method of polishing a workpiece including: a) supplying an unpolished workpiece to first CMP tool 12 for partly polishing said workpiece with a first slurry; b) forwarding the partly-polished workpiece to a second CMP tool 14 for polishing said partly-polished workpiece with a second slurry different from the first slurry. However, Meyer is silent about the limitations of "supplying a first batch".



Referring again to FIG. 1, the chemical slurries **15**, **17** used on each of the polishing stations **12**, **14** are preferably different. While both the first slurry **15** and the second slurry may contain colloidal silica particles and have a basic pH, the slurry **15** used at the first polishing station **12** preferably has larger silica particles, and a higher concentration of solids (~50–70 %), than the slurry **17** used at the second polishing station **14**. The second slurry **17** preferably has very fine particles and low concentration of solids. Any of a number of slurries with particulate and pH characteristics similar to these described above may be used. One suitable slurry for the first slurry **15** is NALCO 2350 diluted in the

With reference to col. 1, lines 64-67, and col. 2, line 55 to col. 3, line 67, Meyer teaches that it is known in the art to have polished the wafer in batch mode in order to increase workpiece throughput in the polishing process.

US 6,224,465 B1

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METHODS AND APPARATUS FOR CHEMICAL MECHANICAL PLANARIZATION USING A MICROREPLICATED SURFACE

TECHNICAL FIELD

The present invention relates, generally, to the configuration of the surface topography of pads used in processing workpieces and, more particularly, to the use of microreplicated structures as a pad surface topography.

BACKGROUND ART AND TECHNICAL PROBLEMS

Chemical mechanical planarization ("CMP") is widely used in the microelectronics industry, particularly for local and global planarization of VLSI devices with sub-micron geometries. A typical CMP process involves polishing back built-up layers of dielectrics and conductors on integrated circuit chips during manufacture.

More particularly, a resinous polishing pad having a cellular structure is traditionally employed in conjunction with a slurry, for example a water-based slurry comprising colloidal silica particles. When pressure is applied between the polishing pad and the workpiece (e.g., silicon wafer) being polished, mechanical stresses are concentrated on the exposed edges of the adjoining cells in the cellular pad. Abrasive particles within the slurry concentrated on these edges tend to create zones of localized stress at the workpiece in the vicinity of the exposed edges of the polishing pad. This localized pressure creates mechanical strain on the chemical bonds comprising the surface being polished, rendering the chemical bonds more susceptible to chemical attack or corrosion (e.g., stress corrosion). Consequently, microscopic regions are removed from the surface being polished, enhancing planarity of the polished surface. See, for example, Arai, et al., U.S. Pat. No. 5,099,614, issued March, 1992; Karlsrud, U.S. Pat. No. 5,498,196, issued March, 1996; Arai, et al., U.S. Pat. No. 4,805,348, issued February, 1989; Karlsrud et al., U.S. Pat. No. 5,329,732, issued July, 1994; and Karlsrud et al., U.S. Pat. No. 5,498, 199, issued March, 1996, for further discussion of presently known lapping and planarization techniques. By this reference, the entire disclosures of the foregoing patents are hereby incorporated herein.

Presently known polishing techniques are unsatisfactory in several regards. For example, as the size of microelectronic structures used in integrated circuits decreases to sub-half-micron levels, and as the number of microelectronic structures on current and future generation integrated circuits increases, the degree of planarity required increases dramatically. The high degree of accuracy of current lithographic techniques for smaller devices requires increasingly flatter surfaces. Presently known polishing techniques are believed to be inadequate to produce the degree of local planarity and global uniformity across the relatively large surfaces of silicon wafers used in integrated circuits, particularly for future generations.

Presently known polishing techniques are also unsatisfactory in that processes designed to produce planar, defect-free surfaces are necessarily time-consuming—involving extremely fine slurry particles in conjunction with porous pads.

Presently known polishing techniques are also unsatisfactory in that traditional polishing pads require periodic conditioning to maintain their effectiveness. As a result, batch-to-batch variations persist, and other complications of the

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conditioning step arise (for example, degradation of the conditioning pad itself).

Microreplicated structures are generally well known in other fields, particularly in the field of optics, where—as a result of their retroreflective properties—microreplicated films have found wide application for use in Fresnel lenses, road signs and reflectors. In addition, larger examples of such structures (on the order of 100 microns in height) have been incorporated into structured abrasive articles useful for grinding steel and other metals (see, e.g., Pieper et al., U.S. Pat. No. 5,304,223, issued Apr. 19, 1994).

In the context of chemical-mechanical planarization, regular arrays of structures (e.g., hemispheres, cubes, cylinders, and hexagons) have been formed in standard polyurethane polishing pads (see e.g. , Yu et al., U.S. Pat. No. 5,441,598, issued Aug. 15, 1995). Such structures are typically over 250 microns in height, and—due to their porosity—suffer from the same asperity variations found in other polyurethane pads.

Chemical mechanical planarization techniques and materials are thus needed which will permit a higher degree of planarization and uniformity of that planarization over the entire surface of integrated circuit structures. At the same time, more efficient techniques are needed to increase the throughput of wafers through the CMP system while reducing batch-to-batch variation.

SUMMARY OF THE INVENTION

In accordance with a preferred embodiment of the present invention, a chemical mechanical planarization process employs a microreplicated surface or pad in lieu of the traditional cellular polishing pad employed in presently known CMP processes. For example, a microreplicated surface useful in the context of the present invention suitably consists of a regular array of precisely shaped three-dimensional structures (for example, pyramids), each of which preferably have sharp distal points. The uniformity of such a microreplicated surface provides enhanced global and local planarization. Such microreplicated pads further provide improved processing of other types of workpieces, including magnetic media, magnetoresistive (MR) heads, texturizing of pre and post-media disks, and polishing of glass and metallic media. These pads further provide a technique for planarizing workpieces with photoresist build-up along their perimeters.

In a preferred embodiment, wherein slurry particles are substantially smaller than the microreplicated structure size, chemical mechanical polishing takes place in two phases. Early on in the process, when the microreplicated surface is fresh and its asperities are relatively sharp, material removal at the workpiece surface is effected primarily through mechanical abrasion between the workpiece and the microreplicated structures. During this phase, abrasive particles in the slurry have little effect on material removal rate. As processing progresses, however, and ablation of the microreplicated polishing surface proceeds, the individual microreplicated structures become dulled. As dulling of the microreplicated structures continues, the chemical-mechanical effects of the abrasive particles become more pronounced. In view of the transitional nature of this process, a microreplicated surface is advantageously employed in a linear belt configuration, wherein the belt moves either continuously or, in a particularly preferred embodiment, advances linearly at the beginning of the process (at the completion of the previous batch of workpieces) in order to provide a fresh microreplicated

Thus, it would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the Mikhaylich et al.'6,431,959 method of polishing wafer with the teaching of polishing wafer in batch mode as taught by Meyer'6,224,465 in order to increase workpiece throughput in the polishing process.

3. Claims 1-3, 18, 19, and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Mikhaylich et al.'959 and Meyer'465 as applied to claim 21 above, and further in view of Joslyn et al.'6,203,404.

Mikhaylich as modified by Meyer has been discussed above, but does not disclose the first slurry being silica oxide and the second slurry being ceria oxide.

With reference to Figures 3-4, col. 3, line 5 to col. 4, line 22, Joslyn discloses a method of polishing a workpiece using a first slurry being silica oxide (col. 4, lin16) in a first polishing pad, and then polishing the partly-polished workpiece with a second slurry using a softer ceria particles and a second polishing pad being different from the first polishing pad (col. 3, line 13). In col. 3, line 20, Joslyn implied that an end-point detection is employed to stop the polishing at the desired thickness. In col. 3, lines 31-50, Joslyn discloses that the first slurry is chosen or designed to remove material of region 30 at a greater rate than does the second slurry. The advantage is to achieve greater overall planarity in the combination polishing (col. 3, lines 50-54).

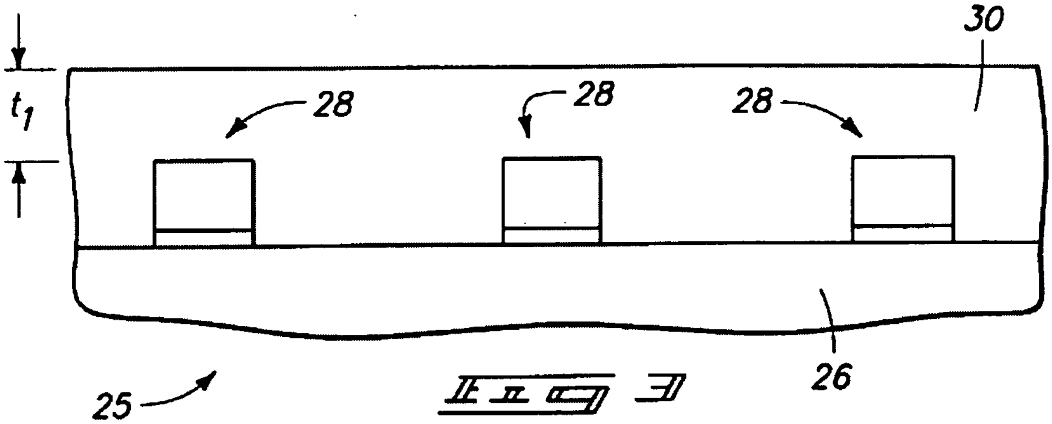

Fig. 3

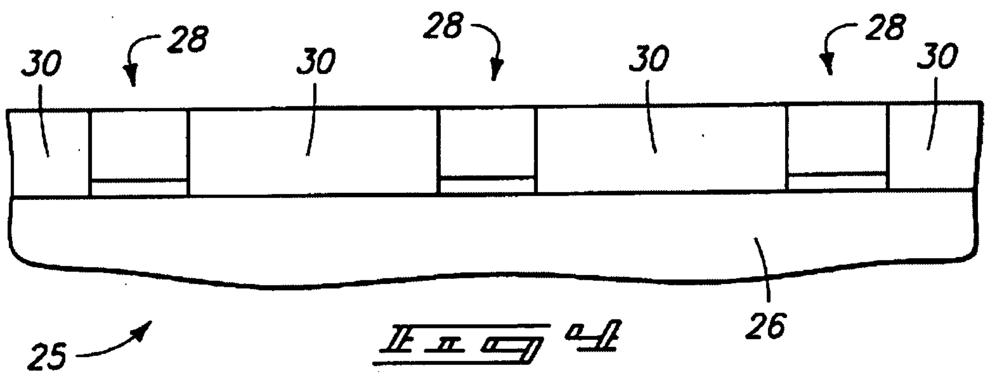

Fig. 4

preferably at least 20%, of thickness t. Further preferably, the amount of thickness t of dielectric material 30 removed to achieve t_1 preferably comprises no more than about 75% of thickness t.

Referring to FIG. 4, dielectric region 30 is chemical mechanical polished on workpiece 25 using a second slurry different from the first slurry, and is referred to as a second chemical mechanical polishing of dielectric region 30. The second chemical mechanical polishing comprises one or both of removal of at least 15% of thickness t or polishing with the same pad used in the first chemical mechanical polishing. Accordingly, the invention contemplates doing both, using different polishing pads but where the second chemical mechanical polishing removes at least 15% of the thickness, or using the same pad but removing less than 15% of the thickness. The depicted example shows polishing of region 30 to a point of stopping proximate outer surfaces of conductive gate lines 28, although the invention is of course not so limited. Other workpieces might be utilized and other stopping points (defined by time, layers, etc. or combinations thereof) could be used. Further, dielectric region 30 might constitute one or more dielectric or other materials. Further, this illustrated preferred example depicts a chemical mechanical polishing method wherein the only chemical mechanical polishing of the thickness of the dielectric region being removed prior to moving the workpiece on to a subsequent nonpolishing processing step are the first and second chemical mechanical polishings. Alternately but less preferred, a third or more subsequent chemical mechanical polishing(s) might be conducted.

A preferred difference between the first and second slurries preferably relates to the aggressiveness or selective nature with which the slurries under an otherwise common set of polishing parameters remove material of region 30. Preferably, the first slurry is chosen or designed to remove dielectric material of region 30 at a greater rate than does the second slurry under an otherwise common set of polishing parameters. In this manner in the preferred embodiment only, the first chemical mechanical polishing is conducted to be more aggressive and achieve greater inherent planarity during the first chemical mechanical polishing than would otherwise occur were the second slurry utilized initially in the first polishing under a same common set of parameters. Thereby, an advantage can be achieved in arriving at greater planarity initially, with the second polish being chosen to be more selective and less aggressive in removing material of the dielectric region. A more aggressive first polishing might have a tendency to leave a scratchy and rougher outer surface than would be desired at the conclusion of the polishing. Yet, greater overall planarity might be achieved in the combination polishing, with the second chemical mechanical polishing using a less aggressive slurry resulting in a smoother, more acceptable outer surface at the conclusion of such polish.

In a preferred embodiment, the first chemical mechanical polishing is conducted to remove dielectric material of the first region at a faster rate than during the second polishing. The first and second polishings can be conducted utilizing the same common set of polishing parameters, other than slurry composition, or using different sets of parameters. Example polishing parameters include ambient temperature, pressure, rotational and translational speeds and movements of the pad and wafer relative to one another, and pressure applied between the pad and the wafer during polishing.

The first and second slurries might differ from one another in one or more numbers of ways. For example, particles in the first slurry might differ in average size from particles in the second slurry. The first slurry might have particles which on average are larger in size than particles in the second slurry in an effort to achieve more non-selective, aggressive removal under an otherwise common set of polishing parameters. For example, a specific average particle size for the first stated chemical mechanical polishing might constitute 120 nm, where an average particle size for the second slurry might constitute 15 nm. Further, the particles in the first slurry might differ in composition from particles in the second slurry. For example, the particles in the first slurry might on average be harder than particles in the second slurry to achieve a more aggressive, faster rate, non-selective polish in the first polishing for an otherwise common set of polishing parameters than in the second polishing. For example, the first slurry might use silica (SiO_2) particles, while softer ceria particles might be used in a second slurry. Further, the particles in the first and second slurries might differ in both size and composition. Smaller and/or softer particles in the second slurry might facilitate formation of a smoother finished outer surface at the conclusion of the polishing. Further, the particles might differ in shape, or in other manners.

Further, the first and second slurries might have substantially the same chemistry but only a difference in particles, for example any or all of the above differences in size, hardness, shape, etc. Alternately by way of example only, the slurries might differ by having different liquid chemistry which attacks the material being chemical mechanical polished with different aggressiveness for an otherwise common set of polishing parameters. By way of example only, one slurry might be basic and the other acidic. Further by way of example only, the slurries might differ in both chemistry and particle attributes. A final polishing is preferably conducted with pure, deionized water (or other solution) which is substantially void of particles (and thereby not a slurry) for purposes of removing an slurry residual material. Typically, negligible, if any, wafer material is removed by such action.

The above-described preferred embodiment depicted removal in only two chemical mechanical polishing steps of the desired thickness "t" of the dielectric region being polished prior to moving the wafer on to some immediate or later subsequent nonpolishing processing step. As referred to above, more chemical mechanical polishing(s) might also be conducted. FIGS. 5 and 6 illustrate alternate processing whereby subsequent polishing can also be conducted which may or may not be chemical mechanical polishing. Like numerals from the first described embodiment have been utilized where appropriate, with differences being indicated by the suffix "a" or with different numerals. FIG. 5 depicts second mechanical polishing occurring subsequent to the polishing of FIG. 3, whereby a thickness "t_2" remains to be removed at the completion of a second mechanical polishing.

Referring to FIG. 6, a third polishing (i.e., chemical, mechanical, or chemical mechanical) of the wafer has been conducted essentially to achieve the FIG. 4 construction.

Where the dielectric material being polished, for example, comprises one or both of doped or undoped silicon dioxide, an example first slurry is ILD 1300™ available from Rodel, Inc. of Newark, N.J., and a second example slurry is KLEBOSOL 30H50™ also available from Rodel, Inc. The ILD 1300™ slurry has a pH of 11, whereas the KLEBOSOL 30H50™ slurry has a pH of 2.6.

Further, consider a workpiece having a 10,000 Angstroms thick layer of dielectric material to be removed by a chemi-

Thus, it would have been obvious to one having ordinary skill in the art at the time the invention was made to have substituted the two different slurries of Mykhaylich et al.'595/Meyer'465 with the teaching of first silica slurry and second ceria slurry as taught by Joslyn because the first silica slurry is chosen or designed to remove material of region 30 at a greater rate than does the second slurry. The advantage is to achieve greater overall planarity in the combination polishing (col. 3, lines 50-54).

Allowable Subject Matter

4. Claims 4-9 and 22-23 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to George Nguyen whose telephone number is 571-272-4491. The examiner can normally be reached on Monday-Friday/630AM-300PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Joseph Hail can be reached on 571-272-4485. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

George Nguyen
Primary Examiner

George Nguyen
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Art Unit 3723

GN – April 08, 2005